EARTH PRESSURE AGAINST SPILL-THROUGH ABUTMENTS

BY

TIEN UN LEE

B.S., Chiao-Tung University, 1940
M.S., University of Illinois, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CIVIL ENGINEERING
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Introduction

The spill-through type of abutment, in contrast to the solid-gravity type, has openings that permit the soil to spill through the abutment and pile up in front at the natural slope of the backfill or at a flatter slope. Although this type of abutment is growing in use, the nature of the earth pressure against it is still a subject of controversy. Opinions differ as to the active pressure against the abutment, the effectiveness of the passive resistance in front of the abutment and the net overturning moment on the abutment. Thus far, all spill-through abutments have been proportioned according to the judgment or intuition of the designers without benefit of rational analysis or experiments. Terzaghi in 1920 pointed out that the evaluation of the earth pressure is an experimental rather than an analytical problem. Therefore, in this thesis the subject has been approached on the basis of experiments on small scale walls with openings of various widths. Supplementary tests on a solid wall have given an opportunity to compare the results with those obtained in past years by other investigators.

Test Program

The test apparatus consists essentially of a box 24″ wide, 24″ long and 12″ high, closed at the front by a vertically suspended wall of which the movement can be controlled and measured. The wall is made of strips which can be taken out to give various widths of openings. The resultant earth pressure at various stages of wall movements is measured by four horizontal and two vertical deflection gages. In each test the wall was premitted to yield in two types of movement, sliding and tilting. The test soil used was standard Ottawa sand. In all, six series of tests were performed. The first series of tests was conducted using a solid wall with soil inside but not in front of the box, corresponding to common retaining wall

tests. The second series of tests consisted of two parts. Part A was performed using a solid wall with soil inside the box and also in front of the wall. This soil in front was spread out at its natural slope in the shape of a half-cone symmetrical about the center line of the wall. The height of the cone was the same as that of the backfill in the box. Part B was performed using a solid wall and with soil inside the box sloping away from the wall at its natural slope. In test series 3, a slot 2″ wide was opened in the center of the wall by taking out the middle 2″ strip. The tests were performed with soil inside the box and with a cone-shaped body of spilled-through soil in front of the wall. Test series 4, 5 and 6 were performed in a similar manner as series 3 but with openings 3″, 4″ and 5″ wide respectively.

Conclusions From Test Results And Tentative Procedures Of Design

The following conclusions are derived from the results of tests using granular soil in a loose state. The recommended procedures of design deal only with earth pressure around the pilasters or columns of the spill-through abutment.

(1). The openings in a spill-through abutment reduce the resultant active earth pressure behind the abutment. The amount of reduction is nearly in direct proportion to the ratio of open width to the total width of abutment.

(2). The negative pressure offered by the soil in front of a spill-through abutment is an important contribution to the stability of the structure. If the abutment is permitted to move until the moments due to active and negative pressures are balanced, the relation between this movement and width of opening may be expressed by the equation $\Delta = (H - 1.5W) / 370$, where Δ is the average movement, H is the height of the backfill and W is the width of the opening expressed as a fraction of H.

(3). Tentative procedures for designing a spill-through abutment are then outlined as follows:

(i) Select a maximum width of opening and a tolerable limit of abutment movement Δ / H. From the selected width of opening W, compute Δ / H from the equation $\Delta = (H - 1.5W) / 370$.

(ii) If the computed Δ / H exceeds the predetermined tolerable limit, the abutment should be designed for the unbalanced overturning moment acting on it at the tolerable movement.

(iii) The heights of the centers of active pressure and negative pressure should be taken as 0.42 H and 0.27 H respectively. The negative pressure is assumed to be equal to the active pressure P'_{AH}. Thus, the resultant overturning moment is equal to $P'_{AH} \times 0.15$ H.

VITA

Tien Un Lee was born in Shantung, China, on February 25th, 1919. He graduated from Chiao-Tung University, Shanghai, China, with the degree of Bachelor of Science in Civil Engineering in June 1940. From 1940 to 1945 he worked for the H-K-K Railroad in China. He came to this country as a gevernment-sponsored Engineering Trainee to the Wabash Railroad in St. Louis, Missouri for one year. Thereafter, he joined the Chinese Supply Commission in Washington, D. C., assisting the purchase of railroad materials.

He began his graduate work at the University of Illinois in September 1947 and received the degree of Master of Science in June 1948. He held a Fellowship in the Civil Engineering Department from September 1948 to June 1949. He was appointed, in September 1949, Special Graduate Research Assistant in the Civil Engineering Department, a position which he now holds.

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